Nonlinear Wave Motion

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Long-Term Goals

My research is directed toward understanding wave generation and wave motion in the ocean and in laboratory simulations thereof.

Objectives

See **Long-Term Goals** above.

Approach

My primary approach is through mathematical models. Solutions ultimately are developed in both analytical and numerical form, but the goal is to obtain analytical results that inform phenomenological models for the prediction of physical events.

Work Completed

[1] Miles, J. "On Janssen's model for surface-wave generation by a gusty wind." *J. Phys. Oceanogr.* **27**, 592-593 (1997).

[2] Miles, J. & Salmon, R. "On the vorticity of long gravity waves in water of variable depth." *Wave Motion* **25**, 273-274 (1997).

[3] Miles, J. "The generation of surface waves by wind: a retrospective." *Appl. Mech. Rev.* **50**, R5-9 (1997).

[4] Miles, J. "A note on the Burgers-Rott vortex with a free surface." *ZAMP* **48** (in press).

[5] Miles, J. & Ierley, G. "Surface-wave generation by gusty wind." *J. Fluid Mech.* (in press).

[6] Miles, J. "The quasi-laminar model for wind-to-wave energy transfer." IMA meeting at University of Salford, U.K. (1997).

[7] Miles, J. & Chamberlain, P. "Topographical scattering of gravity waves." *J. Fluid Mech.* (sub judice).

[8] Miles, J. "On gravity-wave scattering by non-secular changes in depth." *J. Fluid Mech.* (sub judice).

Results

[1,3,5,6] concern surface-wave generation by wind. [3] and [6] are invited review papers dealing with my 1957 quasi-laminar model and its descendents. [1] and [5] concern the effects of gustiness on this energy transfer, developing the models of Janssen (1986) and, especially, Nikolayeva & Tsimring (1986). Gustiness smooths out the critical layer in the quasi-laminar model and typically increases the energy transfer. Nikolayeva & Tsimring had predicted an order-of-magnitude increase in this energy transfer, but this prediction appears to be erroneous, and [5] predicts an increase of 10-30% over most of the wave spectrum.

[2] modifies an analysis of Yoon & Liu (1994) to allow for conservation of potential vorticity in place of their (erroneous) assumption of conservation of conventional vorticity.

[4] extends Rott's (1958) solution of the 'bathtub vortex' problem, which neglects the depression of the free surface, by allowing for a mildly sloping surface. Simple analytical results are obtained for depressions of up to half the ambient depth.

[7] and [8] deal with gravity-wave propagation and scattering in water of variable depth. [7] establishes a hierarchy of equations, starting with the classical Helmholtz equation and comprising the well known mild-slope equation and Chamberlain & Porter's 'modified mild-slope equation', through an operational expansion of the underlying partial differential equations. Approximate solutions are obtained through a 'quasi-geometrical-optics' approximation, which extends the conventional geometrical-optics (ray-theory) approximation by incorporating reflection. [8] attacks the topographical-scattering problem through a functional expansion in the departure of the depth from its flat-bottom mean.

Impact/Applications

I expect that the results of [1] and [5] ultimately could be included in semi-empirical models, such as that of the WAM group, for the prediction of wind-generated waves. Perhaps more importantly, they should contribute to our understanding of air-sea interaction. The results of [7] and [8] are directly applicable to coastal engineering and naval operational problems.

Transitions

Related Projects

References

See **Work Completed**.